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Water Resources

BLACKMUD CREEK
FLOODPLAIN STUDY
SAUNDERS LAKE TO HIGHWAY 2

Alberta
ENVIRONMENT

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ALBERTA DEPARTMENT OF THE ENVIRONMENT
WATER RESOURCES MANAGEMENT SERVICES
TECHNICAL SERVICES DIVISION

BLACKMUD CREEK
FLOODPLAIN STUDY
SAUNDERS LAKE TO HIGHWAY 2

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Blackmud Creek Floodplain Study

by
B.G. Bigornia, P. Eng.*

SUMMARY

This report outlines a study undertaken to determine the water surface profiles and flood risk areas along Blackmud Creek between Saunders Lake and Highway 2. The flood risk areas to the west of the creek (between Saunders Lake and Boundary Road) were delineated for the 1:100 year flood (77.3 cms at Highway 2) and the 1:25 year flood (51.0 cms at Highway 2) on 1 m contour mapping at a scale of 1:5,000. The flood risk areas to the east of the creek were approximated by transferring the calculated water levels onto the aerial photography.

The 1:100 year floodplain is about 530 m wide from Saunders Lake to the Boundary Road bridge, where it reduces to 290 m from here to the Canadian Pacific Railway grade. The average depth of flow in the floodplain is 1.8 m and the average velocity of floodplain flow is less than 0.1 m/s.

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1.0 INTRODUCTION

1.1 Objectives

The purpose of this study is to determine the water surface profile and to delineate flood risk areas for the 1 in 100 year flood along the Blackmud Creek (Figure 1). A 1:100 year flood event is defined as the maximum annual instantaneous discharge having a 0.01 annual probability of being equalled or exceeded. Floodlines and water surface profiles are plotted for the 1:100 and 1:25 year floods.

1.2 Study Reach

As shown on Figure 2, the study reach measures about 10 km in length, involving the confluence of Clearwater and Irvine Creeks, which enter Blackmud Creek about 500 m and 7,200 m (respectively) downstream of the Saunders Lake weir. The weir is the upstream limit of the study reach; the downstream limit is the southbound Highway 2 bridge crossing, 20 km upstream of Blackmud Creek's confluence with Whitemud Creek.

1.3 Background Information

The problem of flooding from Saunders Lake to Highway 2 has been aggravated by a number of factors. The initial channelization, a result of flooding in 1954, has not been maintained and again flooding is a problem. The Blackmud Creek channel has many beaver dams and sand bars which inhibit the passage of flood waters. Also, channel improvements to Irvine Creek, Clearwater Creek and the

LeBlanc Canal increase the frequency of flooding along Blackmud Creek by carrying flood flows more efficiently. Further expansion of the Town of Leduc, the hamlets of Beaumont, Rollyview and New Sarepta, the International Airport and Highway 2, have also increased runoff, adding to the flooding of land along Blackmud Creek(1)*.

Towards reducing the frequency as well as the duration of flooding of Blackmud Creek, the channel was enlargened (in 1984) to accommodate:

a) the 1:3 year flood between Saunders Lake and a point 6 km downstream, and

b) the 1:5 year flood from that point to the Highway 2 bridge.

Modifications were later made to raise the design grade and modify the downstream channel dimensions in order to avoid a buried pipeline crossing.

The above channel modifications necessitated that a new analysis of the extent of flooding along Blackmud Creek be conducted, taking into account the changes in channel bed. This information is required in order to adequately assess industrial subdivision along the Blackmud Creek Valley in the Nisku area.

*Numbers in parentheses refer to numbered references cited at the end of the report.

2.0 HYDROLOGY

Blackmud Creek flows in a northerly direction within the North Saskatchewan River Basin. It contributes a drainage area of 655 km^2 to Whitemud Creek. Whitemud Creek joins the North Saskatchewan River at Edmonton, some 8 km downstream of its Blackmud Creek confluence.

Blackmud Creek is characterized by a large number of lakes within its headwater areas and numerous potholes and sloughs. For higher return period flows, the spring runoff (primarily snowmelt), governs. However, for the less frequent flows, starting at about the 25 year return period event, the summer rainfall events tend to be the governing condition(2). In general, peak flow events on Blackmud Creek are associated with snowmelt events. On occasion, summer storms will account for the maximum annual peak discharges.

Flood peaks for the study area were developed by subdividing Blackmud Creek into three subsystems (Saunders Lake, Clearwater Creek and Irvine Creek) and modelling each of the subsystems. Table 1* summarizes the peak flow rates for various return period floods determined for the Blackmud Creek study area.

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*Hydrologic estimates were provided by Hydrology Branch, Technical Services Division, Alberta Environment(3).

TABLE 1

Flood Frequencies - Blackmud Creek

	Annual Maximum Instantaneous Discharge (cms)				
Return Period Years	below Saunders Lake	below Clearwater Creek	below Irvine Creek	near Ellerslie	at the Mouth
100	37.1	56.4	77.3	83.0	86.9
50	30.9	46.7	64.3	68.2	71.6
25	24.7	37.1	51.0	54.4	57.2
10	16.9	24.9	34.8	37.1	39.1
5	11.6	16.7	23.5	25.2	26.3
2	5.0	6.9	9.8	10.5	11.1

3.0 CHANNEL CHARACTERISTICS

In this section, some of the creek's physical and hydraulic characteristics are presented. Blackmud Creek has relatively low velocities and consequently has little erosion potential, notwithstanding unstable banks.

3.1 Channel Improvements

During 1984, the upstream section of the Blackmud Creek channel was reconstructed to a bottom width of 8 m and sideslopes of 3H:1V. The downstream section was constructed to a bottom width of 15 m and sideslopes of 3H:1V. The channel was constructed at a gradient of 0.0026 m/m from the Saunders Lake weir to a point 110 m upstream of the Airport Road bridge, 0.00010 m/m from this point to the Highway 2 (southbound) bridge, and 0.000 m/m (i.e., flat) from here to a point 50 m downstream. Below this point, the channel was cleared at a gradient of 0.00040 to the Service Road bridge.

3.2 Hydraulic Characteristics

During the 1 in 100 year flood, the creek flows at a mean velocity of 0.05 to 1.0 m/s with a depth of 2.8 to 5.3 m. The floodplain width at this discharge ranges up to 700 m, the average being 520 m.

The 1 in 25 year flood is confined closer to the creek and flows with a mean velocity of 1.1 to 1.4 m/s at a depth of 1.3 to 3.0 m. The floodplain for this discharge ranges up to 560 m, the average being 250 m.

3.3 Surveys

The cross sectional data used for this study included 18 cross sections of the Blackmud Creek floodplain. These were surveyed by the Survey Branch, Technical Services Division of Alberta Environment in June 1984. A supplementary survey was carried out by the River Engineering Branch in September 1984, to determine flow conditions downstream of the study reach.

The cross sections in the channel section where improvements have taken place are based on the design grades and dimensions prepared, and later modified by Stewart, Weir and Co.(1).

Typical cross sectional plots are shown in Figure 4.

4.0 CALCULATION OF FLOOD LEVELS

4.1 Methodology

The mathematical computer model (HEC-2) used to generate water surface profiles for this study was developed by the U.S. Army Corps of Engineers' Hydrologic Engineering Centre(4). The 'HEC-2' program uses Bernoulli's theorem for the total energy at each cross section and Manning's formula to determine the friction head loss between cross sections. The assumptions inherent in this method are: quasi-uniform gradually varied flow, a rigid bed, direction of flow perpendicular to the cross section, and uniform water surface elevation across the entire cross section.

The HEC-2 program requires geometric, hydrologic and hydraulic data input to compute the water surface profiles. The geometric component was provided through surveyed cross sections. The hydrologic component was provided by the estimated discharges for different frequency return periods (Table 1). The hydraulic component was satisfied through the use of Manning's roughness coefficients or 'n' values which are based on characteristics of the study reach.

4.2 Manning's Roughness Coefficients

The hydraulic roughness coefficient (Manning's n-value) defines the resistance to flow of a channel and its floodplain. For estimating the roughness values (n), each cross section is divided into channel and overbank areas. The overbank areas are further subdivided based on land use and vegetative cover. After a review

of aerial photography and a field inspection of the cross sections, n-values were assigned to each cross section. Well established overbank and channel n-values developed by Chow(3) were used as a guideline. Example values are shown in Table 2.

TABLE 2

Manning's Roughness Coefficients (n)

	Minimum	Normal	Maximum
Excavated or Dredged			
a) Earth, straight and uniform			
1. Clean, recently completed	0.016	0.018	0.020
2. Clean, after weathering	0.018	0.022	0.025
3. Gravel, uniform section	0.022	0.025	0.030
4. Short grass, few weeds	0.022	0.027	0.033
Floodplains			
a) Pasture, no brush			
1. Short grass	0.025	0.030	0.035
2. High Grass	0.030	0.035	0.050
b) Cultivated areas			
1. No crop	0.020	0.030	0.040
2. Mature row crops	0.025	0.035	0.045
c) Brush			
1. Medium to dense brush	0.070	0.100	0.160
d) Trees			
1. Heavy stand of timber	0.080	0.100	0.120

By reconstructing the channel to new dimensions, the hydraulic flow conditions were changed from that of its previous state. Thus, high water levels recorded during past peak flows could not be used

to calibrate the computer model. The channel was assigned a roughness of 0.030 to allow for future growth of vegetation.

4.3 Sensitivity

The sensitivity of the water surface profile was tested by varying the main channel roughness coefficient from 0.022 to 0.033. The increase in water level was only 0.04 m over this range for the 1:100 year flood event (77.3 cms). Blackmud Creek was found to be insensitive to adjustment of the roughness coefficient (n) at high flood levels.

The water surface profile's sensitivity to the downstream water level, however, was very high. A small change of 0.2 m would raise or lower the profile a similar amount for nearly the entire study reach. This would transfer to a change in floodplain width of about 10 m for the 1:100 year flood event.

4.4 Starting Water Surface Elevation

The peak discharge for the 1974 flood was estimated(3) to be 72.2 cms at the Highway 2 bridge crossing of Blackmud Creek. This is very close in magnitude to (within 7% of) the 1:100 year peak discharge at this point. The highwater mark recorded by Alberta Transportation at the inlet of the southbound Highway 2 crossing was 690.74 m. Though the recent upstream channel works render upstream highwater marks unusable, the level recorded at the bridge site would remain representative to the reach, since the hydraulic characteristics of the channel below this point are basically unchanged from 1974. The geometry of the inlet was used with the

highwater mark to derive a rating curve for the starting flood levels.

5.0 MAPPING OF THE BLACKMUD CREEK FLOODPLAIN

The base mapping used for Blackmud Creek was 1:5,000 contour mapping having a contour interval of 1 m. The 1978 mapping was prepared by Topographic Services Ltd. and provided by Stewart Weir and Co. The contour mapping is limited to coverage of the west side of Blackmud Creek from Saunders Lake to the Boundary Road Bridge.

Delineation of the flood risk maps was achieved by plotting the calculated water surface elevations onto the available contour mapping (i.e., west of the creek). By determining where the water surface would intersect the ground profile, the aerial extent of flooding was determined. Between cross sections, the contour lines were used to guide the determination of the extent of flooding.

Where no contour mapping was available (i.e., east of the creek), the extent of flooding was located at each cross section by examining the individual cross sectional surveys. Between cross sections, the aerial extent of flooding was estimated from an examination of aerial photography. The photography used was flown May 1982 at a scale of 1:10,000 and on September 1982 at a scale of 1:30,000. The air photo mosaics were enlarged to a scale of 1:5,000 to produce Figures 6B, 6C, 6D and 6E. The detailed location plan for these figures may be found on Figure 6A

Flood risk areas were then transferred onto the photograph mosaic of the study reach. It must be emphasized that scaling from these photos is not possible due to distortion of the final enlargement.

REFERENCES

1. "Blackmud Creek and Irvine Creek Drainage Improvement Project, County of Leduc No. 25, Stewart, Weir and Co., August 1983.

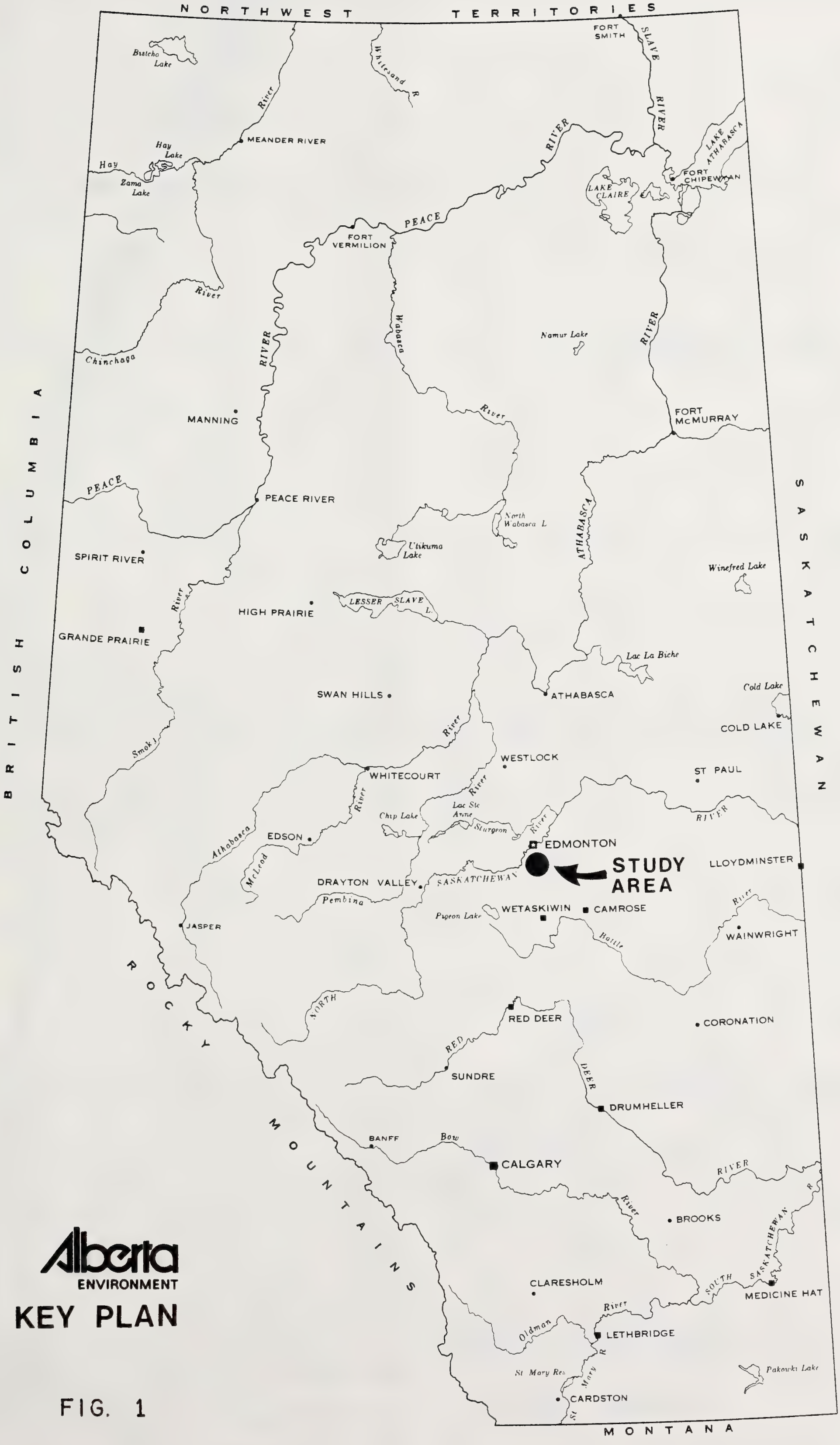
2. "Highway 2 Industrial Park, Blackmud Creek Investigation", Stanley Associates Engineering Ltd., October 1980.

3. "Blackmud Creek Flood Frequency Analysis", Deboer, A, Hydrology Branch, Technical Services Division, Alberta Environment, June 1984.

4. "Open Channel Flow", Chow, V.T., McGraw Hill Book Company, 1959.

5. "HEC-2 Users Manual", U.S. Army, Corps of Engineers, Hydrologic Engineering Centre, January 1981.

FIGURES



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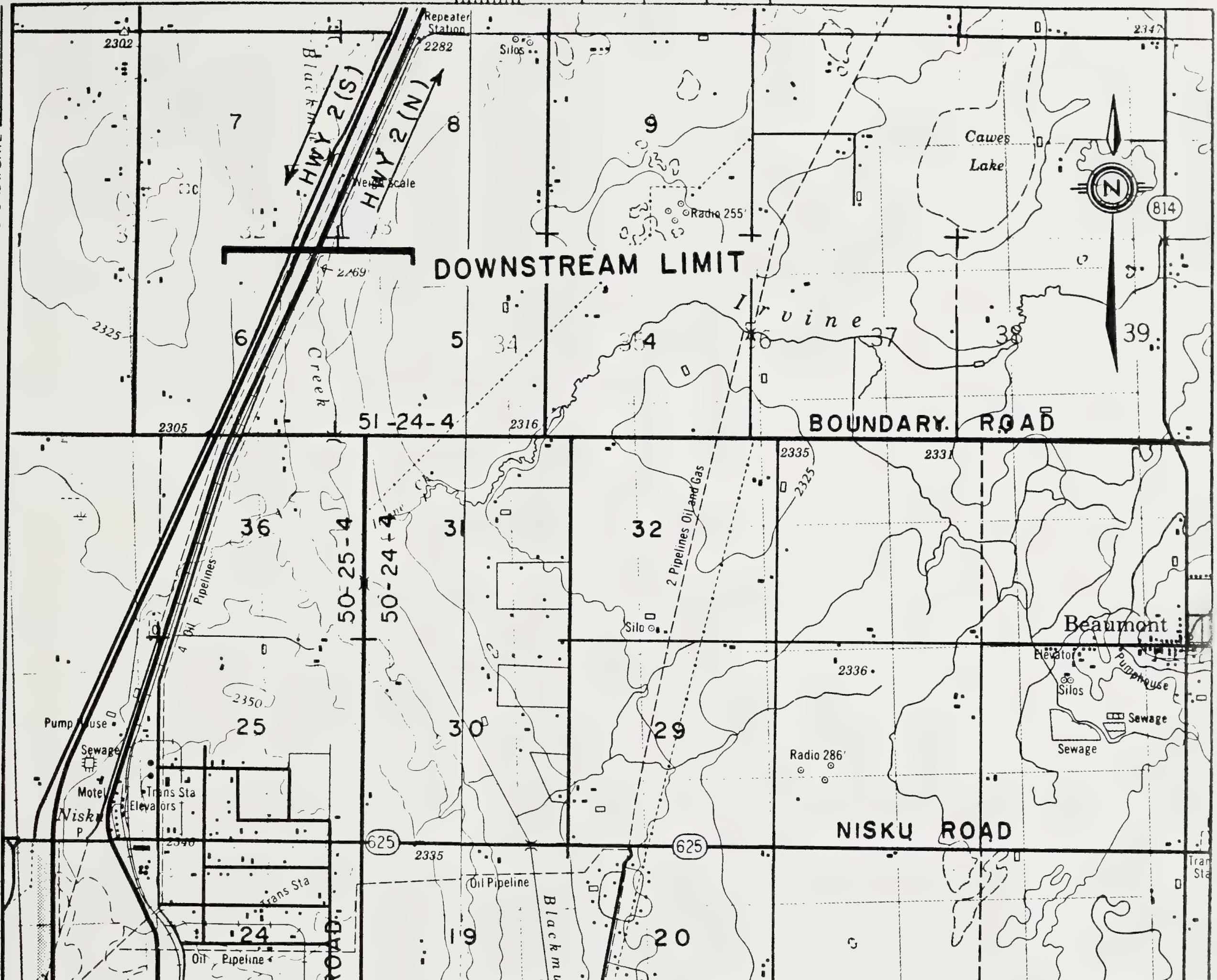
KEY PLAN

FIG. 1



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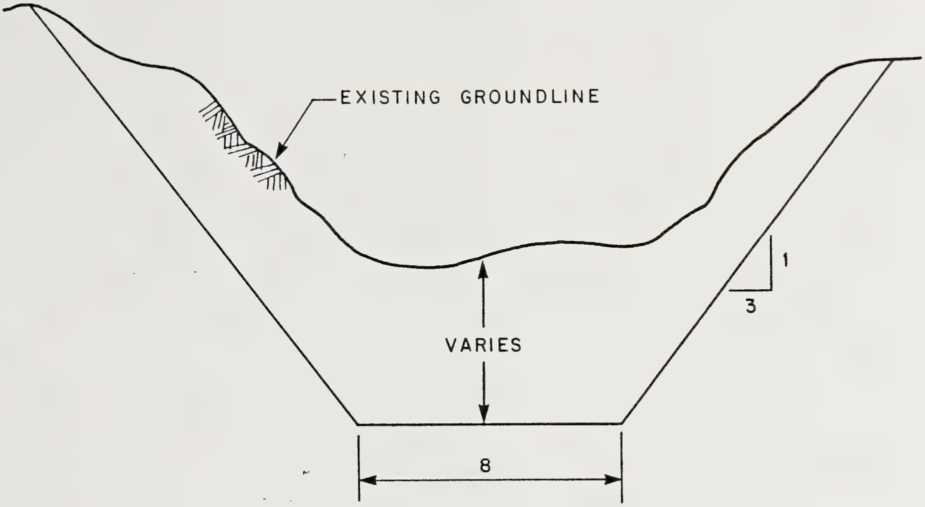
DESIGNED	B.G.B.	SCALE 1 : 50 000	BLACKMUD CREEK FLOODPLAIN STUDY
DRAWN		DATE	STUDY REACH
CHECKED		SHEET 1 OF 1	FIGURE No. 2

RIVER ENGINEERING BRANCH

P4-215 x 280



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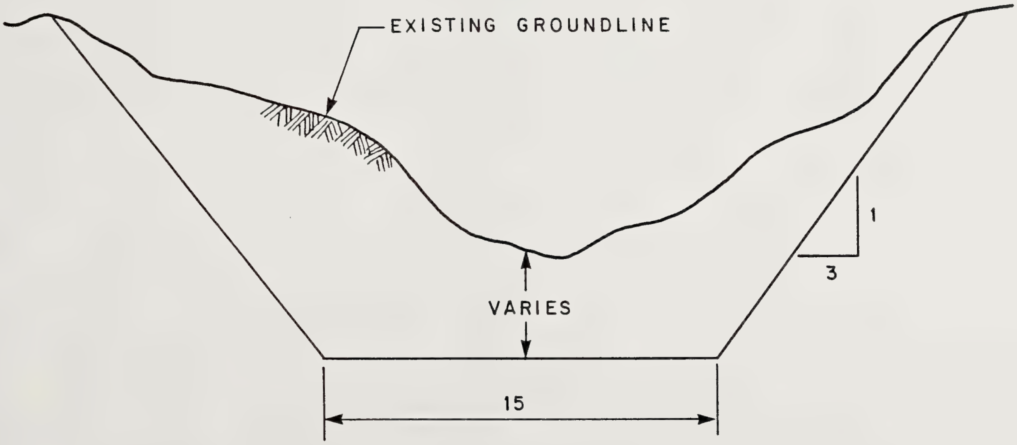

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(1 : 5yr. capacity)

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RIVER ENGINEERING BRANCH

DESIGNED J. LEE
DRAWN
CHECKED

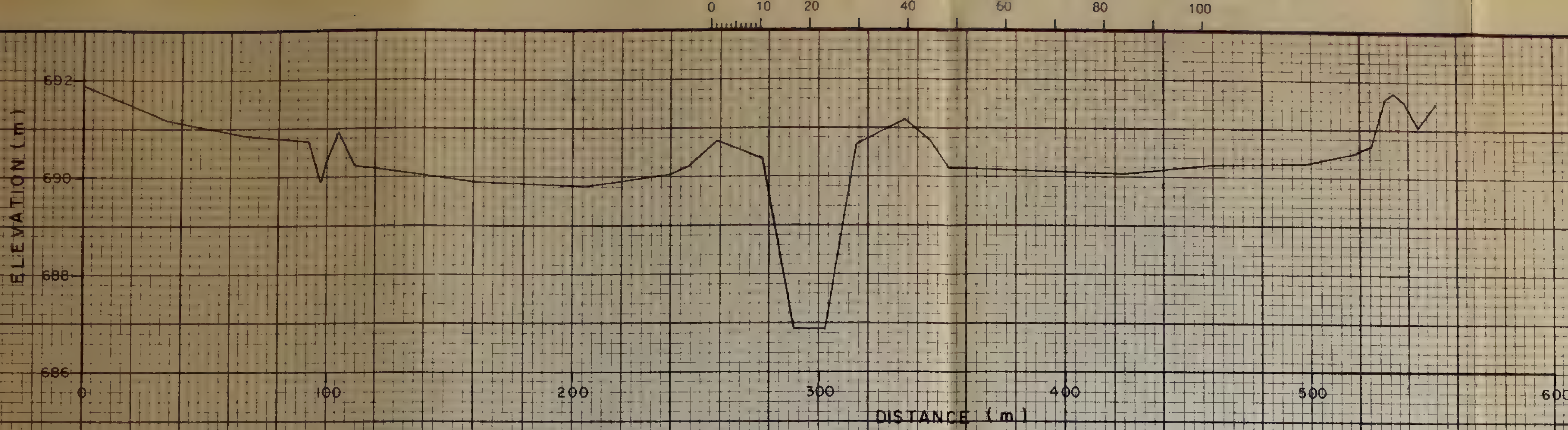
SCALE N.T.S.
DATE
SHEET OF

BLACKMUD CREEK FLOODPLAIN STUDY

CHANNEL IMPROVEMENTS

FIGURE No. 3

MICROFILM DATE



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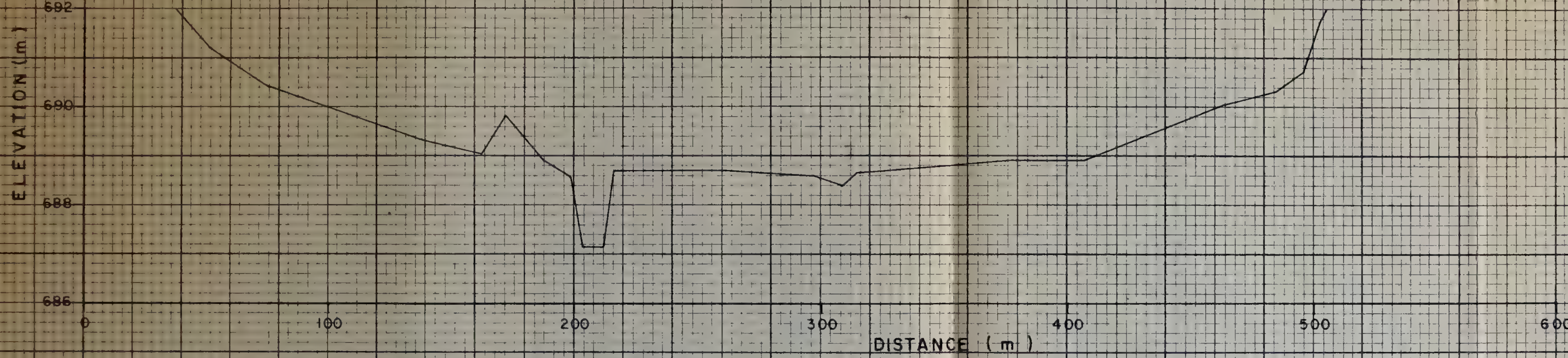

CROSS - SECTION 8

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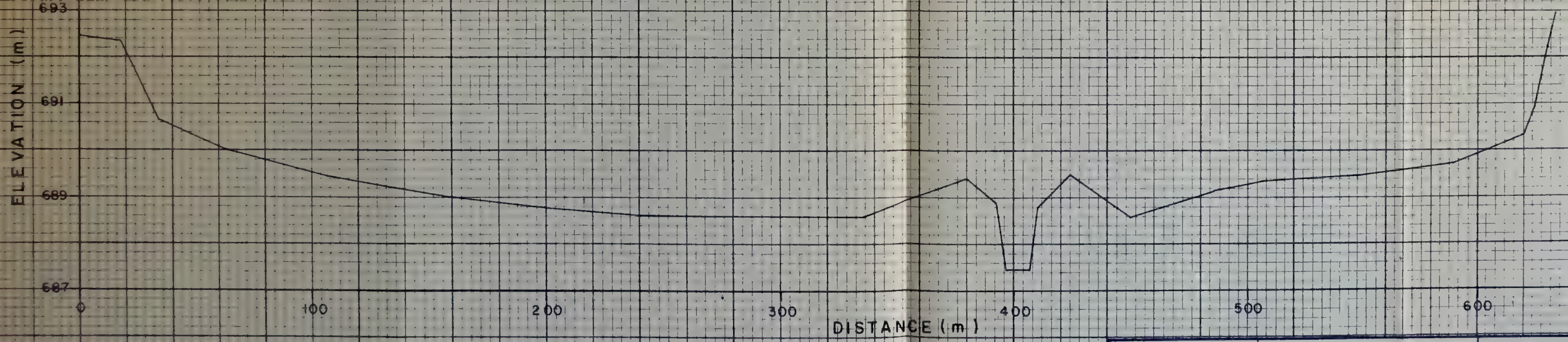


CROSS - SECTION 12

Alberta ENVIRONMENT

RIVER ENGINEERING BRANCH

DESIGNED B.G.B.

DRAWN C. Auenlauser

CHECKED P. LaRocque

SCALE VERT. 1:100; HOR. 1:2000

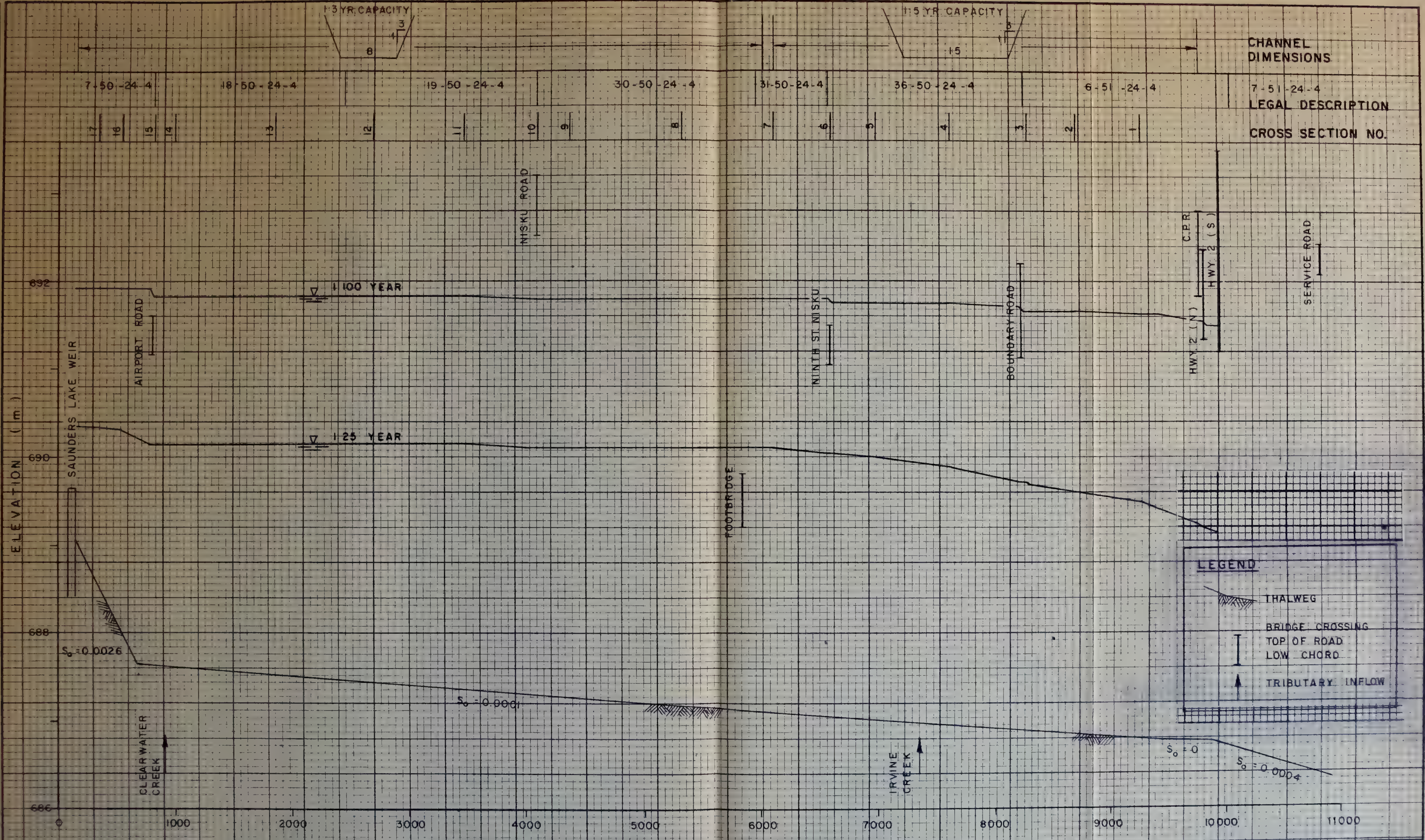
DATE

SHEET 1 OF 1

BLACKMUD CREEK FLOODPLAIN STUDY

TYPICAL CROSS SECTIONS

FIGURE No. 4



MICROFILM DATE

DRAWING FILE No.

Alberta
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RIVER ENGINEERING BRANCH

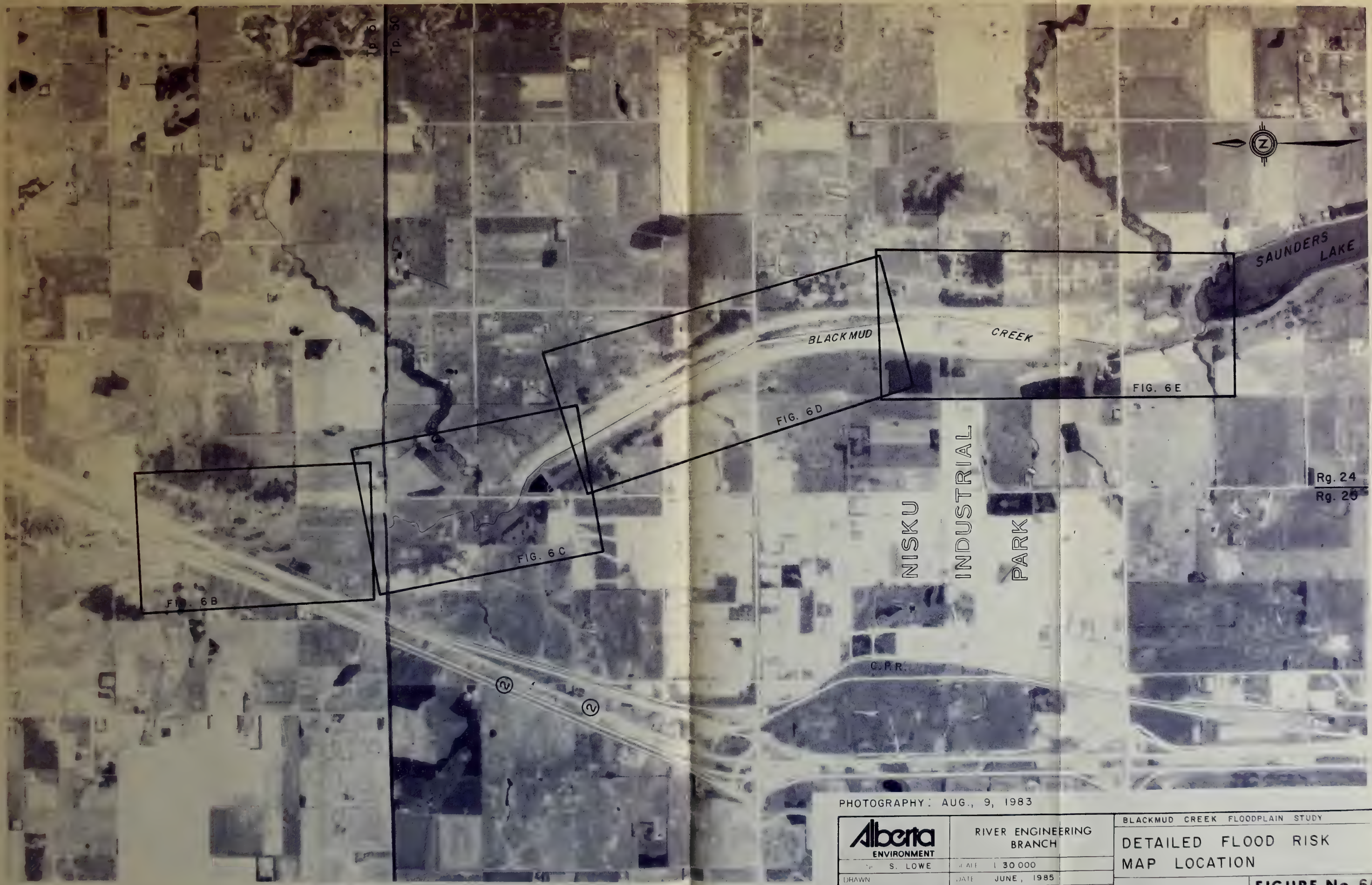
BLACKMUD CREEK FLOODPLAIN STUDY

WATER SURFACE PROFILES
(1:25; 1:100 YEAR FLOODS)
BLACKMUD CREEK

FIGURE No. 5

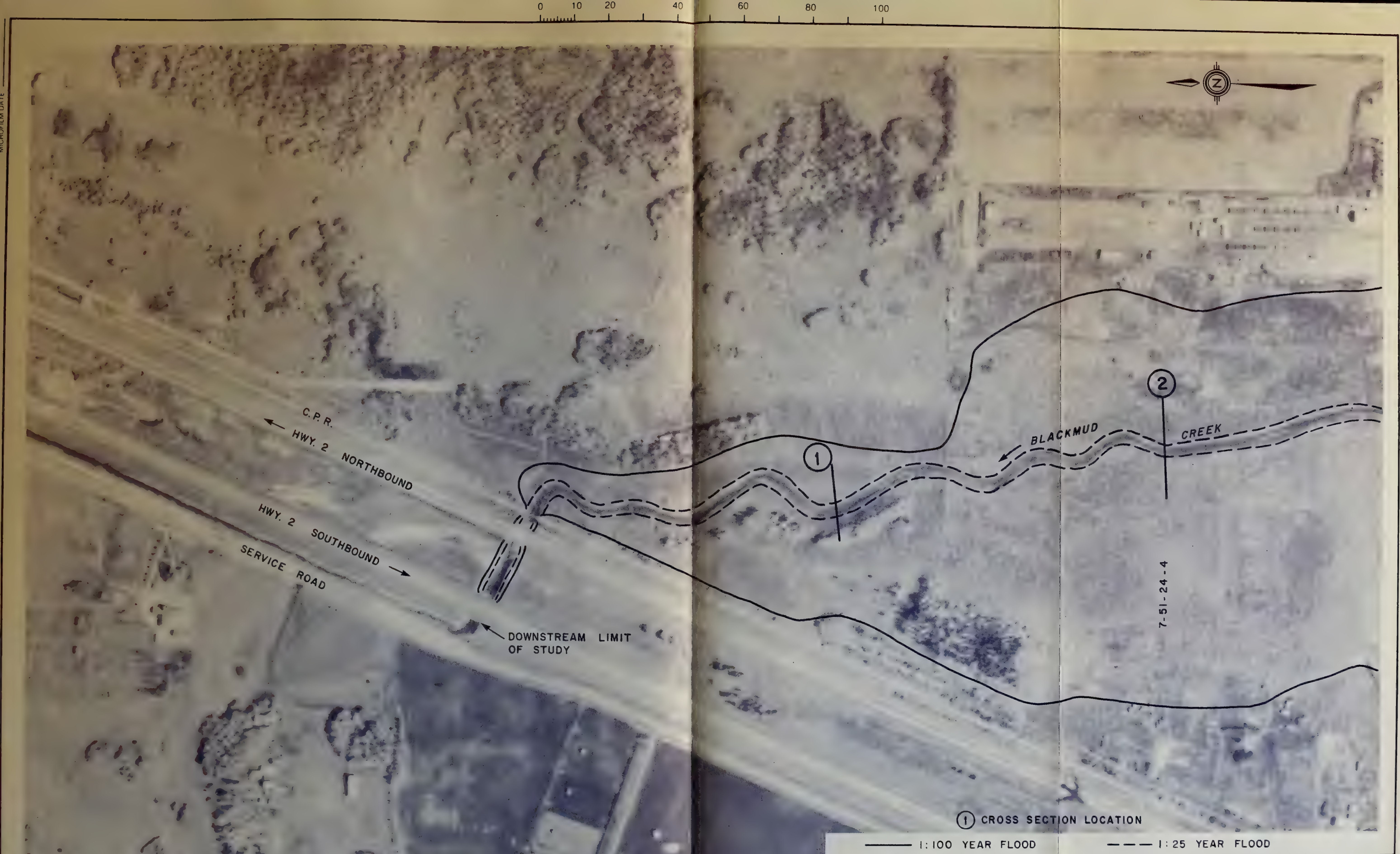
DESIGNED B.G.B.
DRAWN C. [illegible]
CHECKED P. LaRocque

SCALE HOR. 1:30000; VERT. 1:40
DATE
SHEET 1 OF 1



PHOTOGRAPHY: AUG., 9, 1983

Alberta ENVIRONMENT	RIVER ENGINEERING BRANCH	BLACKMUD CREEK FLOODPLAIN STUDY
S. LOWE	SCALE 1 30 000	DETAILED FLOOD RISK MAP LOCATION
DRAWN	DATE JUNE, 1985	
CHECKED	SHEET 1 OF 5	**FIGURE No. 6A**

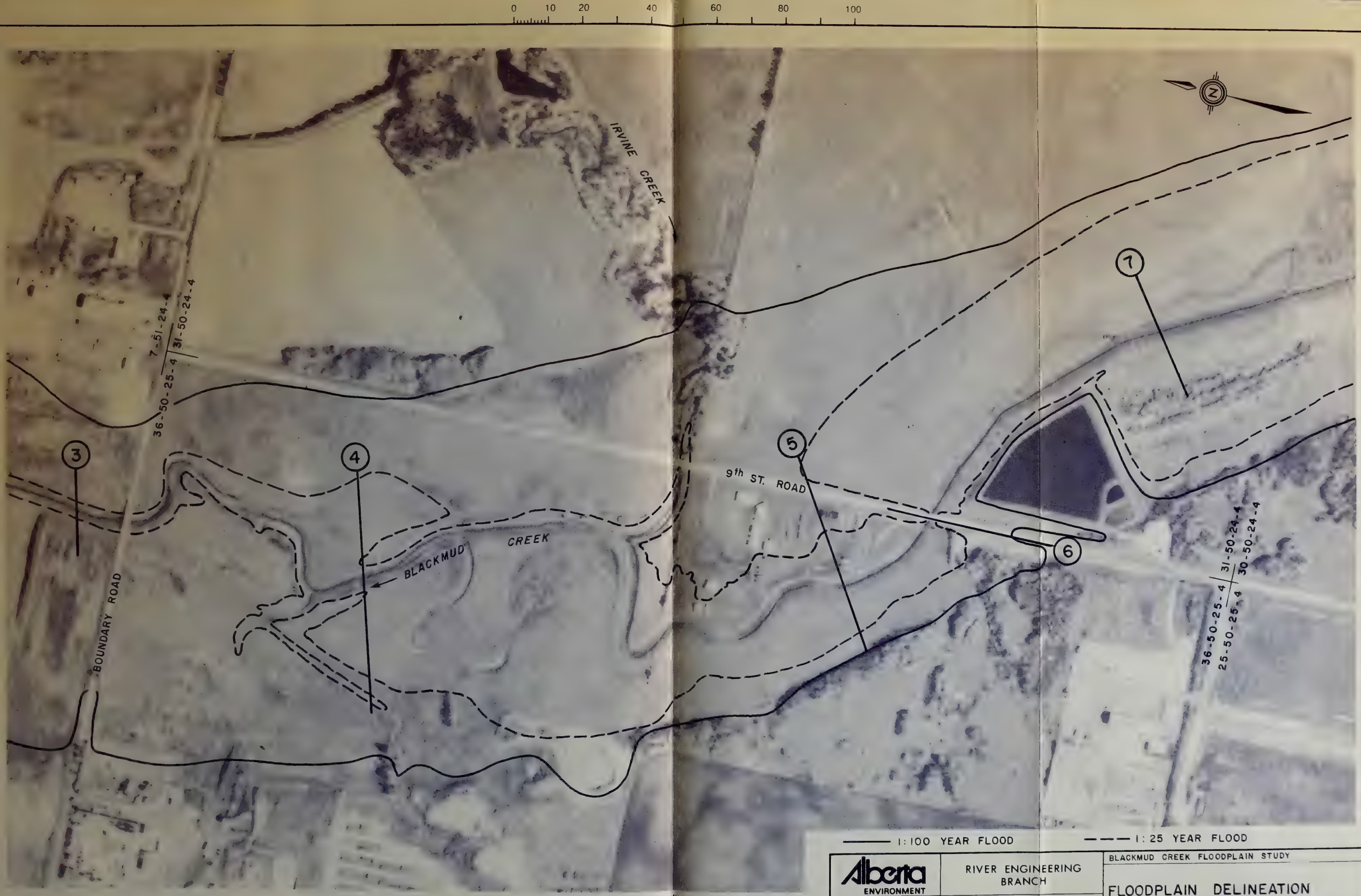


AERIAL PHOTOGRAPHY FLOWN SEPT. 30, 1982

Alberta ENVIRONMENT	RIVER ENGINEERING BRANCH	BLACKMUD CREEK FLOODPLAIN STUDY FLOODPLAIN DELINEATION
DESIGNED P. LaRocque	SCALE 1 : 5000	
DRAWN B. Sanders	DATE DEC., 1984	
CHECKED	SHEET 2 OF 5	FIGURE No. 6B

MICROFILM DATE

DRAWING FILE No



AERIAL PHOTOGRAPHY FLOWN SEPT. 30, 1982

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RIVER ENGINEERING
BRANCH

BLACKMUD CREEK FLOODPLAIN STUDY

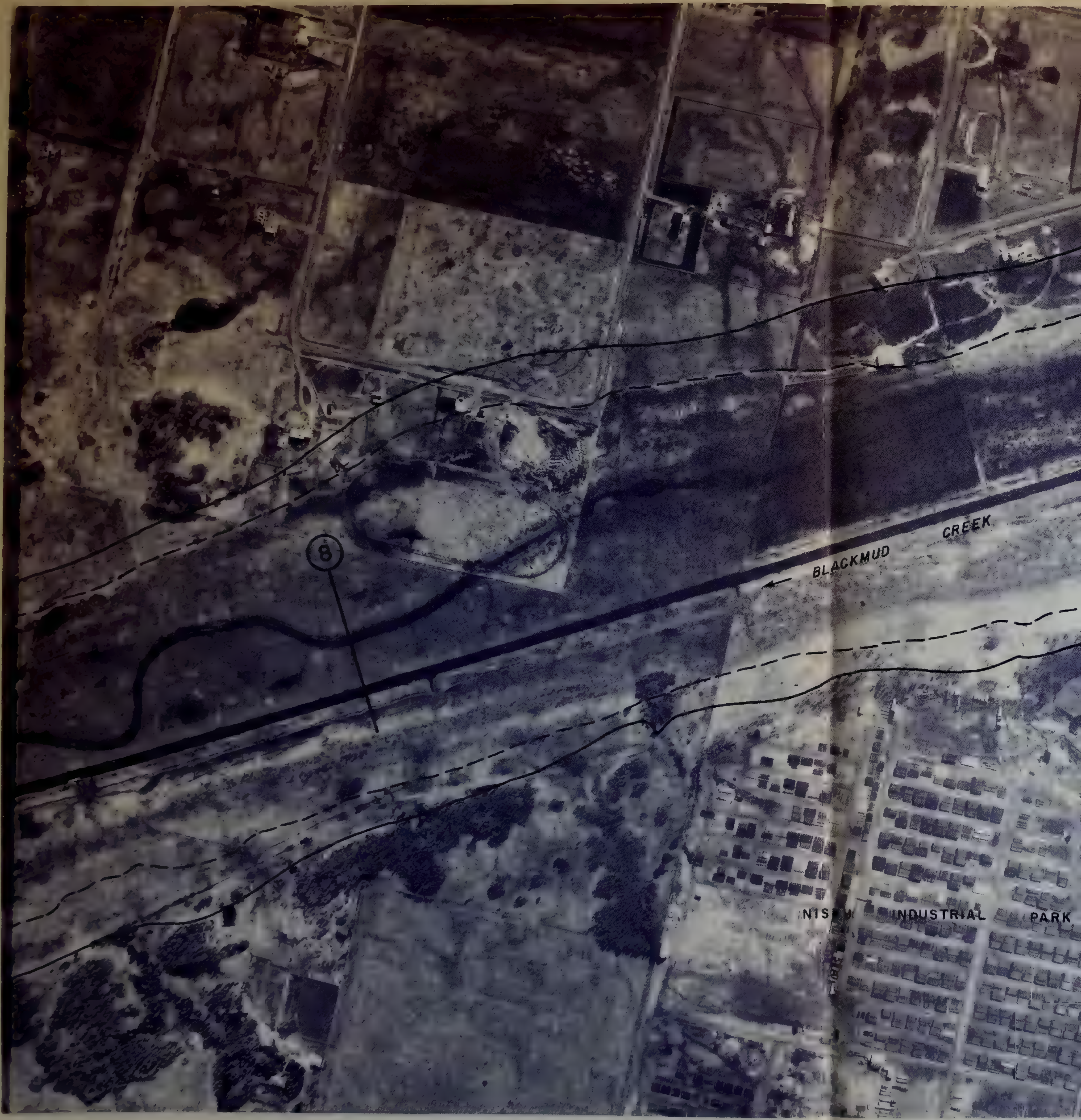
FLOODPLAIN DELINEATION

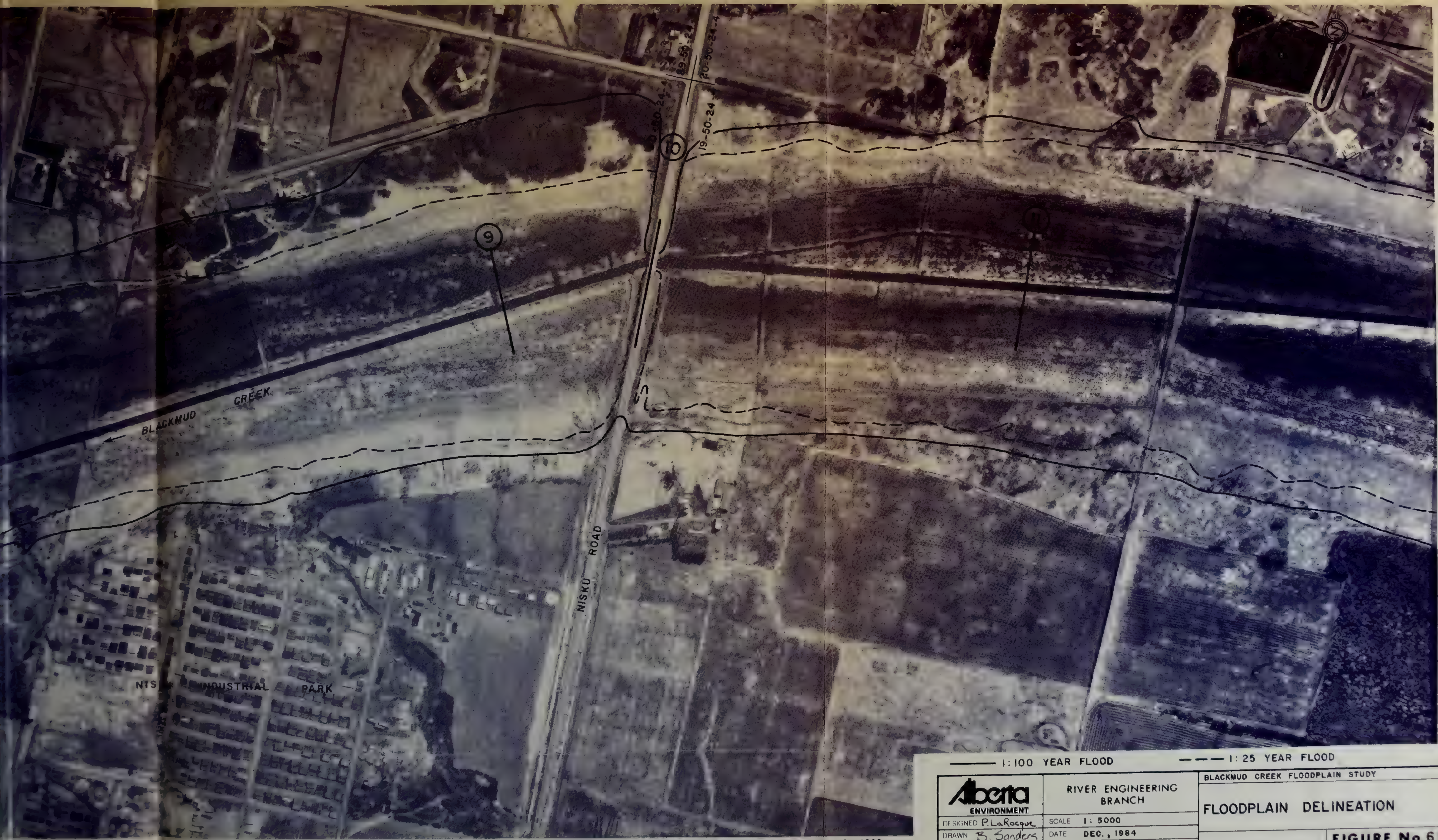
DESIGNED P. LaRocque
DRAWN B. Sanders
CHECKED

SCALE 1 : 5000
DATE DEC., 1984
SHEET 3 OF 5

FIGURE No. 6C

MICROFILM DATE





AERIAL PHOTOGRAPHY FLOWN MAY 13, 1982

——— 1:100 YEAR FLOOD

– – – 1:25 YEAR FLOOD

Alberta ENVIRONMENT	RIVER ENGINEERING BRANCH	BLACKMUD CREEK FLOODPLAIN STUDY FLOODPLAIN DELINEATION
DESIGNED P. LaRocque	SCALE 1: 5000	
DRAWN B. Sanders	DATE DEC., 1984	FIGURE No.6D
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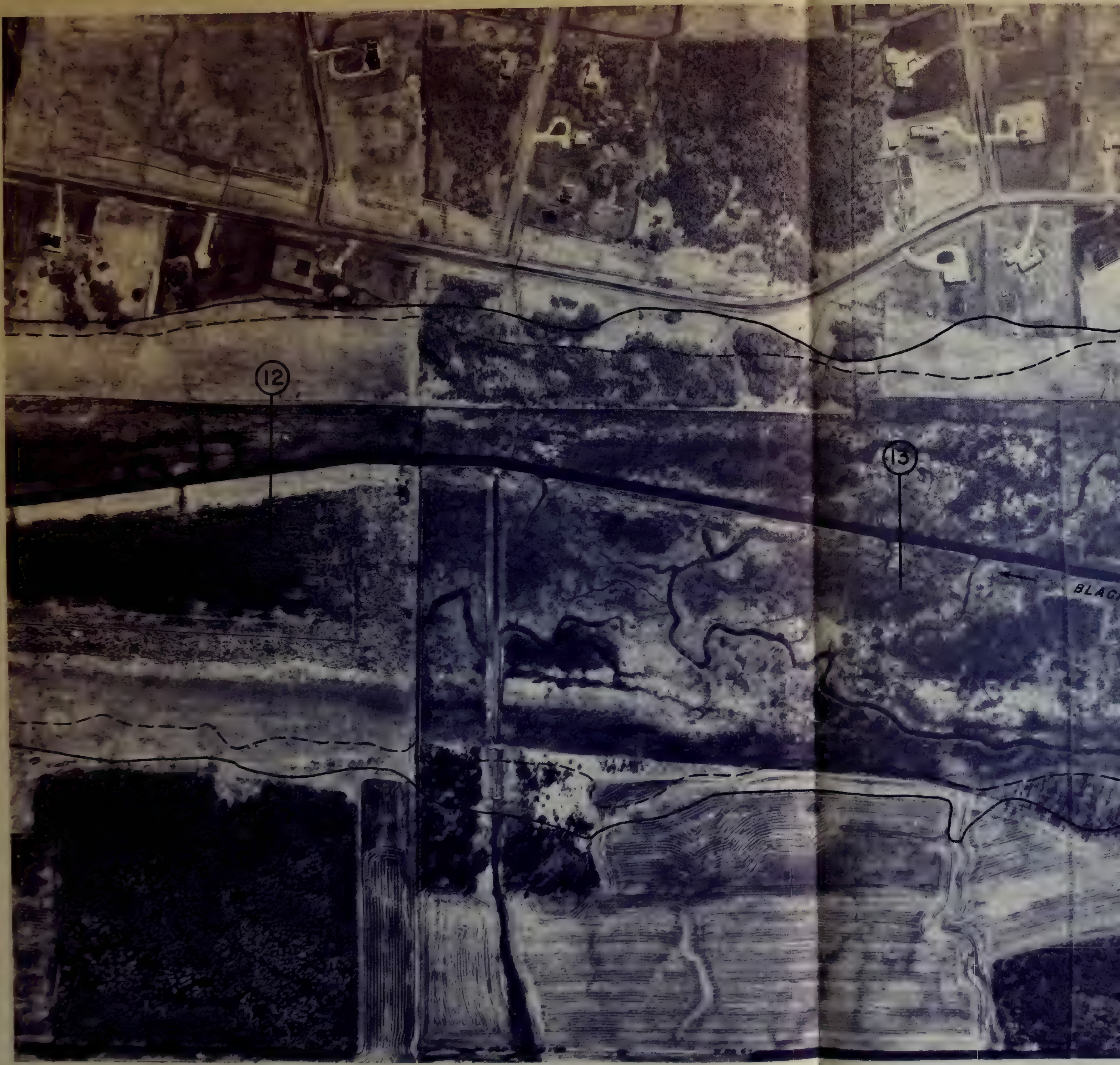
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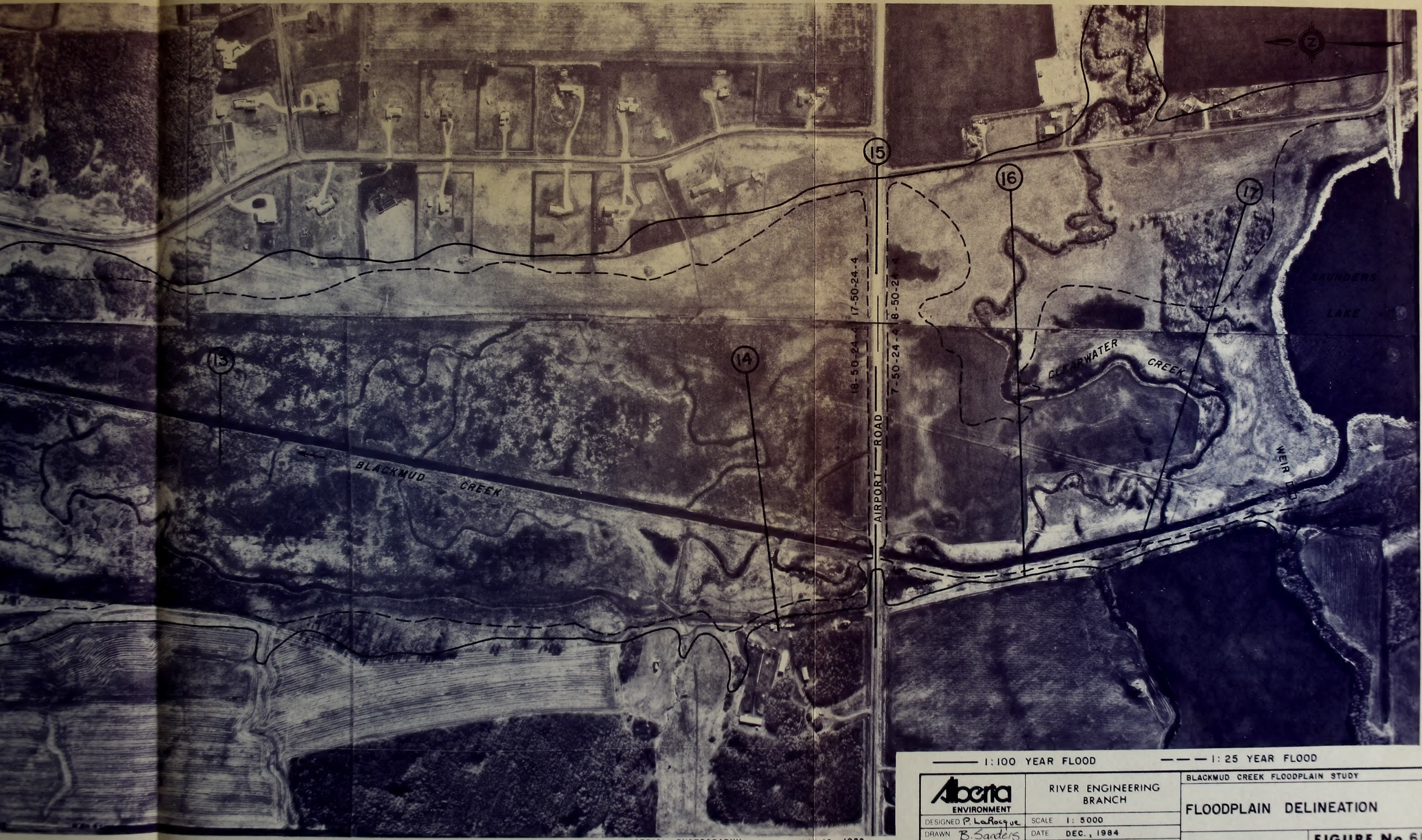

——— 1:100 YEAR FLOOD

— — — 1:25 YEAR FLOOD

AERIAL PHOTOGRAPHY MAY 13, 1982

Alberta ENVIRONMENT

RIVER ENGINEERING BRANCH

BLACKMUD CREEK FLOODPLAIN STUDY

FLOODPLAIN DELINEATION

DESIGNED P. LaRocque	SCALE 1:5000
DRAWN B. Sanders	DATE DEC., 1984
CHECKED	SHEET 5 OF 5

FIGURE No. 6E

N.L.C. - B.N.C.
3 3286 07920192 3